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~~Title:~~ The development of a protocol for diagnosing hand dermatitis from photographic images

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Ethics: Ethical review and approval to conduct the study was granted by the Health Research Authority- NRES Committee London, City Road and Hampstead (reference: 13/LO/0981)

ABSTRACT

Background

A hand photography protocol was needed to ascertain the presence and severity of dermatitis in a trial testing the effectiveness of a behaviour change intervention to prevent hand dermatitis in nurses.

Methods

We developed the protocol in three stages: (i) established a procedure for collecting hand photographs; (ii) conducted a stepwise validation process to agree rules for diagnosing and determining severity of hand dermatitis and; (iii) trained a research nurse to screen out 'clear' cases.

Results

We developed and trained fieldworkers (n=97) in a procedure for collecting hand photographs. Study dermatologists established interpretation rules to diagnose and determine the severity of dermatitis from photographs. Prior to the establishment of the rules, inter-observer agreement between the two dermatologists on the presence or absence of hand dermatitis was moderate (kappa 0.5). At the final stage of the validation process, the dermatologists agreed on 88% cases from independent assessments, with consensus reached for the remaining 12% following joint deliberation. Following training, a subgroup analysis of 250 cases screened by the nurse and characterised as 'clear' found two (0.8%) 'positive' cases were missed.

Conclusion

We have developed a hand photography protocol, which may be used in other studies or in hand dermatitis health surveillance programmes.

Key words: photographs, photography protocol, hand dermatitis, nurses, research trial.

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1. Introduction

: Hand dermatitis is recognised as a major occupational skin disease for ~~frontline~~ primary healthcare workers (1, 2), with the point prevalence among healthcare workers estimated to be 24% compared to less than 10% in the general population (3). While various methods and tools have been developed to diagnose and assess severity of hand dermatitis (4-9), limitations in their acceptability have been observed. In particular, these approaches typically rely on visual inspections and clinical assessments by clinicians in clinical settings or by patient self-assessment. This renders many of them of limited use in large population-based intervention studies where clinical follow-up may be impractical due to the dispersed nature of study participants. -

Teledermatology is a mature ~~application~~approach, which yields results similar to those of face-to-face consultations (5, 13). There is also supportive evidence that interpretation of digital photographs is sufficiently sensitive to detect early signs of dermatitis (13). Teledermatology has been shown to have high intra- and inter-rater reliability when compared with face-to-face assessment in NHS intensive care nurses and nursery nurses (5), with a slight tendency to over-estimate the prevalence of hand dermatitis (5, 6, 13). The self- assessment of hand dermatitis (or no 'clear' hand dermatitis) by healthcare workers and non-healthcare workers using the photographic method proposed by Coenraads et al (11) has also been shown to be an effective approach in several studies (14-16). However, this method could not be used in the present trial as study participants needed to be blinded to the assessment of whether hand dermatitis was present or not, as this was the primary outcome of the trial. In addition, we required a method, which would reliably distinguish dermatitis towards the milder end of the spectrum.

The purpose of this paper is to describe the three distinct stages we took in developing a new hand photography protocol for the skin care intervention in nurses (SCIN) trial in the United Kingdom. This new protocol offers a method for diagnosing hand dermatitis and its severity which relies on dermatologist and research nurse inspection of hand photographs from research participants (in lieu of physical examinations), with comparisons then made from standardised images contained in Coeraands et al photographic guide (11). The stages include: (i) developing a standardised procedure for hand photography (ii) a stepwise validation process of rules for the study dermatologists to diagnose and determine the severity of the hand dermatitis and (iii) training by a dermatologists of a research nurse to screen out hand photographs of study participants without dermatitis ('clear cases'). In developing the new method, we had several requirements:

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1. The method had to measure presence or absence of hand dermatitis as well as severity.
2. The method could not involve physical examination of the participants, as that would be logistically very difficult, expensive and likely to result in poor response rates.
3. The method had to be objective and not based on self-report as self-report tends to over-report hand dermatitis.
4. The severity scale needed to be able to distinguish dermatitis towards the milder end of the disease spectrum.

2. Methods

2.1 Study background

The skin care intervention in nurses ('SCIN') trial is a national multi-centre cluster randomised controlled trial examining the effectiveness of a complex intervention to reduce the prevalence and incidence of hand dermatitis in at-risk nurses working in the National Health Service (NHS) in the United Kingdom (1). We recruited two groups of nurses who are at risk of hand dermatitis: student nurses who had a history of atopic ~~tendency~~ disposition and intensive care unit (ICU) nurses due to higher frequency of hand washing. The main study intervention is based on an online behaviour change programme (BCP), grounded in the theory of planned behaviour (17) combined with provision of hand moisturisers and optimal equipment for hand care. We recruited 2042 participants from 35 participating sites in the N~~ational H~~ealth S~~ervice~~. Each participant had four photographs taken of their hands at baseline (left palmar, left dorsal, right palmar, right dorsal) and four photographs of their hands at 12 months ~~follow~~ follow-up. Several fieldworkers (occupational health practitioners and research nurses) at each site were trained by the central trial team and were responsible for recruiting study participants and collecting study data, this included taking hand photographs.

The primary outcome measure was the difference in the point prevalence of hand dermatitis between participants in the intervention and control arm of the trial from baseline (T1) to 12 months (T2) on photographs assessed by the two study dermatologists.

~~**Methods**~~

2.2: ~~Stage 1:~~ Development of the hand photography procedure and fieldworker training (Stage 1)

In collaboration with a medical photographer, we developed a detailed hand photography procedure to standardise the collection, screening and assessment of hand photographs. This provided fieldworkers with step-by-step instructions on setting up and using high-resolution digital SLR cameras for taking the hand photographs from each participant (see appendix 1). A flexible grey/white photographic exposure card was used as a background screen when taking the photographs. The hand photography procedure required fieldworkers to check the correct settings of camera set up functions, that the camera flash ~~is~~ was switched on, and that a minimum distance (75cm) of the camera from the participants' hands ~~is~~ was maintained (11). Before the trial started we trained fieldworkers in the use of the photography protocol, including practical photography demonstrations. During the follow up period, we also provided participants with an opportunity to take hand photographs on their smart phones and send them to the research team via email. Specific instructions on how to take and send in hand selfie photographs were sent to participants and these were based on key aspects of the main photography protocol'

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2.3 ~~Stage 2:~~ Establishing agreed assessment rules for diagnosing hand dermatitis and for ascertaining the severity of dermatitis (Stage 2)

We assessed hand dermatitis via photographic images taken of each two side of the hand (palm and dorsum) of both left and right hands i.e. four images per participant. The presence of dermatitis was based on comparisons made with the standardised images of severity at various stages of diseases that were contained in Coenraads et al photographic severity guide (11). For each of the four images, the study dermatologists were required to indicate whether dermatitis was "clear" (absent), "almost clear", "moderate", "severe", or "very severe" for each image. These four variables (dermatitis in the right hand at the back, right hand in the palm, left hand at the back, and left hand in the palm) were then dichotomised as clear vs almost clear/moderate/severe/very severe in any of the four images per participant. A single binary variable was generated for the presence of dermatitis (No / Yes). Agreement/disagreement on the severity of hand dermatitis was not assessed during the validation process since we realised early on that the likelihood of our two dermatologists agreeing on the severity grading (five grades) at four different sites was likely to be poor and that perfect agreement according to each site was not necessary for our study that sought to establish a global estimate of hand dermatitis severity. We took the pragmatic view that each participant's overall severity of hand dermatitis would be defined as the most severe combined score from both dermatologists on the Coenraads et al scale from their four hand photographs. Agreement between the two dermatologists on the binary rating (Yes / No) was assessed using the Cohen's kappa statistic.

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In a prior feasibility study before setting agreement rules of diagnosing dermatitis between the same dermatologists, we found a moderate (kappa 0.5) interobserver agreement in the assessment of photographs. This was mainly due to disagreement on the threshold of very mild versus no dermatitis. The study dermatologists therefore established rules for undertaking the assessments in the main study. To complete this task, we undertook the following stepwise validation process. The study dermatologists were provided with hand photographs from an initial sample of 70 cases (study one) from the main study population to independently assess for dermatitis followed by a further enriched sample of 71 cases (study two) with a high percentage of dermatitis cases (as identified by the chief investigator). To minimise bias, we ensured the study dermatologists remained blinded to any other participant information such as self-reported information in the questionnaires or each other's independent assessment outcomes. The study dermatologists independently scored the hand photographs using the photographic assessment guide developed by Coenraads et al (11). Discordant cases were then identified by the central trial team and sent back to the study dermatologists who remained blinded to other information about the participants for their follow up joint assessment. Both dermatologists looked at the discordant cases together and explained why one or other had decided that the participant had some degree of hand dermatitis. Very often these discordant cases were very difficult to judge and so a set of rules were developed which are referenced in appendix 2. The study dermatologists met and jointly refined these 'mini rules' for deciding whether a case met the criteria for dermatitis. This validation process was repeated again (study three). A final arbitrator (an independent dermatologist) was available for consultation in circumstances where the study dermatologists were unable to agree. The intra-observer error was calculated to determine the degree of error in the dermatologist assessments. Diagram 1 outlines flowchart for assessing hand photographs.

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2.4 ~~Stage 3:~~ Dermatology research nurse training (Stage 3)

Due to the large number of hand photographs collected during the trial, we appointed a dermatitis research nurse to screen out all the photographs where no dermatitis was evident. This cut down on dermatologist time as they only assessed those images the dermatology research nurse was unsure or sure that dermatitis was present.

One of the study dermatologists provided the nurse with two hour training sessions, including the following assessment principles: (i) a quick look for abnormal erythema

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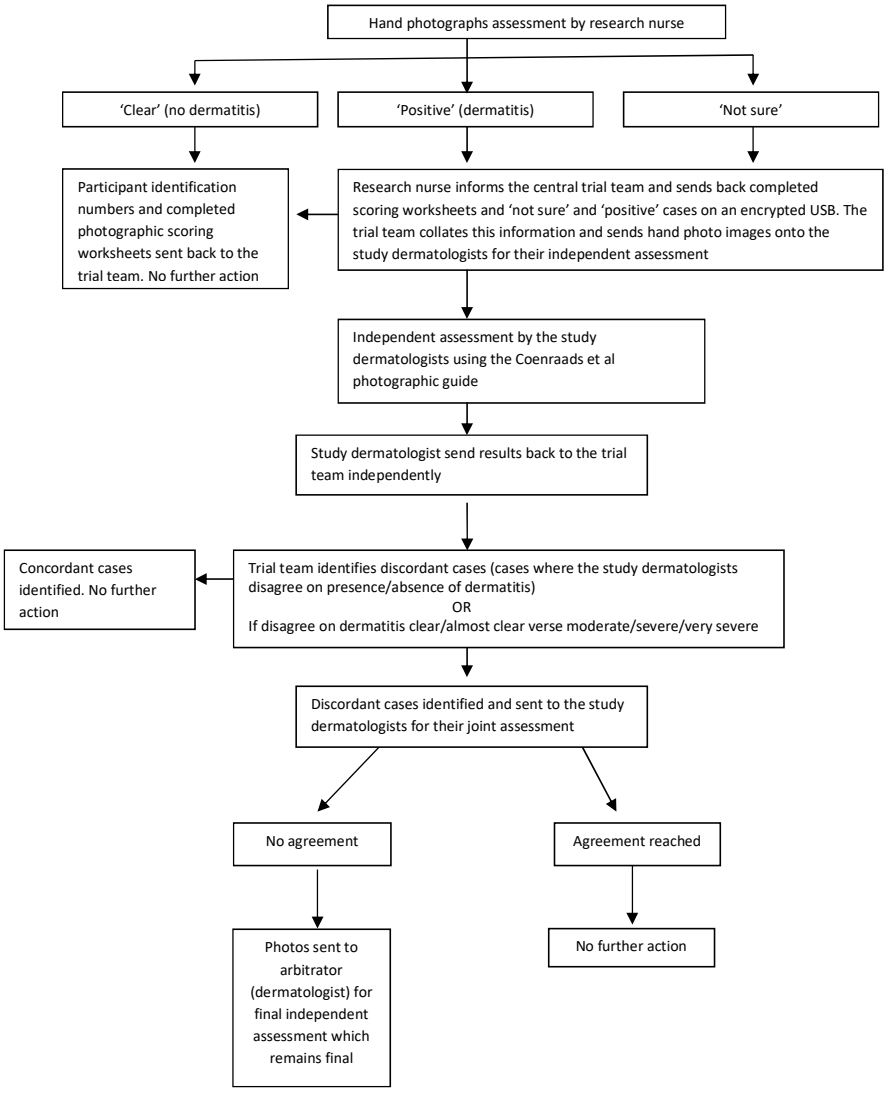
(or surface changes) using pattern recognition skills; (ii) if suspicious areas were identified, images were enlarged to lifesize (but not beyond) to determine if the abnormality was dermatitis (poorly defined erythema with surface change such as scaling, lichenification or vesicles) and (iii) if the research nurse ruled out evidence of dermatitis on first inspection, a final inspection was carried out by the research nurse on high risk areas such as fingers, interdigital webspaces or around rings if worn, and easily missed areas such as the wrist. We ensured the dermatology research nurse was also aware of the agreed rules that the study dermatologists would adhere to during their own assessment process.

To ensure the screening by the dermatology research nurse had a high specificity, we conducted a subgroup reliability analysis. A subsample of 250 cases (images of the dorsum of the right hand only) from the main study population that were initially assessed by the dermatology research nurse as 'clear' (no dermatitis) were sent to one of the study dermatologists for assessment (study four) as this is the area where occupational hand dermatitis is most likely to be seen.

~~Diagram~~ Figure 1: Flowchart for assessing hand photographs



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3. Results

~~Stage 1:~~ 3.1 Procedure for taking hand photographs (Stage 1)

We trained ninety-seven local fieldworkers from 35 participating sites in the use of the hand photography protocol. To differentiate the specific time points in which the hand photographs were taken ('recruitment' T=0 month or 'follow up' T=12 months) we used specific photographic label cards containing unique sequence codes to which the dermatologists and research nurse were blinded. We sent regular reminders to fieldworkers to ensure the correct label cards were being used during the follow up period. Moreover, it became evident following the recruitment period that fieldworkers occasionally forgot to use the camera flash when taking hand photographs. This meant that there were a number of sets of hand photographs (n=10) that could not be included in the final data set due to the difficulties in conducting a reliable assessment due to their poor image quality.

3.2 ~~Stage 2:~~ Establishing agreed assessment rules for diagnosing hand dermatitis and for ascertaining dermatitis severity (Stage 2)

From the initial sample of 70 sets of hand photographs from the main study sent to the study dermatologists for independent assessment as part of our validation process (study one), we found they agreed on 66/70 (94%) cases and disagreed on 4/70 (6%) (kappa 0.30). From the ~~follow~~ follow-up enriched sample of 71 sets of hand photographs sent to the study dermatologists for independent assessment (study two), the proportion of agreements versus disagreements is shown (Table 1) (kappa = -0.14).

-After joint discussion, the study dermatologists agreed on all 29 cases that they had previously disagreed on.

Of the additional 100 photographs from the main trial that were sent to the study dermatologists for their independent assessment as part of our final validation process (study three), a further 12 (12%) discordant cases required joint deliberation. Following discussion, the study dermatologists agreed on all of the 12 cases. The final arbitrator was not used during the development of the photography protocol or during the main trial. This stepwise validation procedure allowed the study dermatologists to further refine their rules for diagnosing hand dermatitis until the inter-observer agreement exceeded a kappa score of 0.60. A full list of the mini rules is in appendix 2.

The joint review of discordant cases showed that one of the dermatologists had a lower threshold for diagnosing dermatitis than the other study dermatologist. In particular, one of them was more likely to grade dryness as meeting the criteria for dermatitis. Therefore, the study dermatologists agreed to exclude very borderline cases of non-inflamed dermatitis as not meeting the criteria for dermatitis. Agreement/disagreement on severity of hand dermatitis was not assessed during the validation process. Table 2 shows the results from the intra-observer assessment of the 71 cases that were randomly selected from the baseline database and were reassessed by the dermatology research nurse and of the 53 cases that were randomly selected from the baseline database and were reassessed by the study dermatologists.

Figure 1 is an example which shows early signs of hand dermatitis which both study dermatologists agreed during their independent assessment, Figure 2: a moderate case of dermatitis and Figure 3, dry and crinkly skin but assessed as 'clear'.

~~Figure 1: Illustrates presence of early stages of hand dermatitis appearing under ring~~

~~Figure 2: Moderate case of hand dermatitis~~

~~Figure 3: Dry and crinkly skin but assessed as 'clear'~~

3.3 ~~Stage 3:~~ Dermatology research nurse training (Stage 3)

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From the subgroup analysis of the 250 cases (images of the dorsum of the right hand only) that were screened by the nurse and categorised as 'clear', the study dermatologists found two 'positive' (0.8%) cases of hand dermatitis had potentially been missed (study four). The study dermatologists suggested that both cases could be considered possible cases of dermatitis because one image had dermatitis on the right lateral surface of the right thumb (i.e. not the back of the right hand which was the primary site for the subgroup analysis) and the other showed dermatitis on the right index finger, although the photograph was underexposed and was difficult to interpret.

4. Discussion

We developed a novel and practical photography protocol suitable for use in a large-scale multi-centre research trial examining hand dermatitis prevention in nurses. The hand photography procedure was a useful instructional guide to promote standardisation of hand photography for later diagnostic assessment. During the stepwise validation procedure, we gained a number of important insights into the complexities of the independent assessment process, which required careful deliberation and refinement. This played an important role in formulating an agreed list of assessment rules to use as a reference guide during the study. We found that hand photographs taken by trained field workers using high-resolution digital SLR cameras provided a practical method for collecting the data on presence or absence of dermatitis in participants who were geographically dispersed across the UK. We successfully trained a dermatology research nurse to competently pre-screen hand photographs as 'clear' (no dermatitis), 'positive' (present dermatitis) or 'not sure', thereby reducing the assessment burden on the study dermatologists. The use of a broad range of hand photographs, showing varying degrees to asymptomatic and symptomatic dermatitis, played an important role during the dermatology research nurse training sessions.

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An important observation from our study is that high quality photographic images of hands will always reveal small areas of scaling, erythema and surface changes that could be deemed to be very early signs of hand dermatitis. This observation reinforces the view that hand dermatitis is a continuum from surface damage to frank dermatitis with cardinal signs such as lichenification and vesicles. Furthermore, we found that agreement between the dermatologists on moderate or severe cases was very good whereas agreement on the gradation between very mild and simply dry "overwashed" hands is more difficult and therefore to be expected. To address this issue, we incorporated a joint assessment

procedure and mini rules that the study dermatologists followed when assessing borderline cases to minimise the risk of misdiagnosis. Such an approach will always be needed in population (as opposed to clinic) based studies where the threshold for diagnosing disease is blurred and difficult to assess.

~~What this paper adds~~

- ~~We have developed a novel hand photography protocol which successfully allowed us to determine the presence, absence and severity of hand dermatitis in participants of a national multicentre trial~~
- ~~Experienced dermatology research nurses can be competently trained to screen out 'clear' cases of hand dermatitis from hand photograph.~~
- ~~The protocol could readily be adopted for use in clinical practice (e.g. hand dermatitis health surveillance) and future research studies.~~
- ~~An important lesson learned during this study was the need to establish an agreed set of rules when two or more assessors are involved in conducting a diagnostic assessment of hand dermatitis from photographs.~~

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Figure legends

Figure 1: Flowchart for assessing hand photographs

Figure ~~1~~2: Illustrates presence of early stages of hand dermatitis appearing under ring

Figure ~~2~~3: Moderate case of hand dermatitis

Figure ~~3~~4: Dry and crinkly skin but assessed as ‘clear’

Online supplement Appendix 1: Procedure for taking hand photographs

See separate upload file

Appendix 2: Rules that were followed by the assessors when screening and diagnosing hand dermatitis from hand photographs

Stage 1: Guiding rules for nurse screening out 'clear' cases	
1	Scan the image of the hands quickly using a pattern recognition approach rather than focussing down on specific areas
2	If the eye detects something possibly abnormal, such as erythema, then focus in on that area
3	Enlarge image to no more than life size to avoid over-interpretation of normal 'wear and tear' dryness in nurses hands
4	Task is only to screen out clear cases and not to decide whether dermatitis is present or not
5	End decision is 'clear', 'not sure' or 'dermatitis'
Stage 2: Guiding rules of dermatologists to diagnose dermatitis	
1	Same as nurse for pattern recognition, but now main purpose is to decide dermatitis yes/no in the enriched sample screened by the nurse.
2	Dermatitis (positive): ➢ Given that damaged skin barrier to subclinical dermatitis to overt dermatitis is a continuum, the greatest challenge is in defining a reasonable threshold for clinically significant dermatitis. The rule we adopted was ill-defined erythema that had to be associated with surface change (scaling, lichenification or vesicles) in the same lesion
3	Dermatitis (negative): ➢ Dryness alone (which is common in nurses who wash their hands 30-40 times a day) was NOT deemed to indicate the presence of dermatitis ➢ Other clinically obvious skin diseases that are not dermatitis eg psoriasis or lichen planus or vitiligo ➢ Isolated paronychia or ragged cuticles ➢ Erythema of knuckles with increased skin markings ('wear and tear' knuckles from increased manual work)

381

382

Table 1: Results from the study dermatologists' independent assessment

Classification (n=71)	Agree	Disagree
Clear (no evidence of dermatitis)	2 (3%)	-
Positive (presence of dermatitis) on either hand	39 (55%)	29 (41%)
Positive (presence of dermatitis) but disagreement on which hand	1 (1%)	

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Table 2: Intra-observer assessment

	Agreement	Kappa
Dermatology research nurse	81.7%	0.56
Dermatologist 1	69.8%	0.40
Dermatologist 2	81.1%	0.63

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